29 Sept 05

Conversation with Dave McGinnis (FNAL accelerator physicist)

I explained that we were trying to determine if a version of KOPIO would be practical at the Booster, and how it would work if it were.

His story was not exactly the same as that of Eric Prebys where it overlapped. To some extent he filled in details, but he also seemed to have a somewhat different vision. He saw the goal of the proton upgrades as a 2MW proton source, WITHOUT a proton driver. He would prefer the latter, but feels it's not too likely, and getting less so every time there's a big hurricane. His plan, like the one described by Prebys seemed to involve at least four stages, but they didn't seem to correspond to Prebys' stages (which were also the ones laid out in the Proton Plan document).
My version is unofficial. Stage numbering isn't that important. The only thing the "Proton Plan" has been approved for is slip stacking in the Main Injector (Stage 1 in my document)

McGinnis mentioned a limit on the average Booster batch intensity that I hadn't previously appreciated. Although a single batch of 5E12 is possible, they can't maintain this as an average. For 8 Hz operation they can average 4.7E12. But for 15 Hz operation, they are not counting on more than 4E12/batch. This creates a certain coupling between KOPIO running off the Booster and the current default plan for NOVA, as I'll try to make clear below.

He talked about "Stages", but I don't think they correspond to the Stages in the Proton Plan document. His "Stage 2" involved running the Booster at 8 Hz, then momentum stacking the batches in the Recycler. (No, I assume slip stacking in the Recycler for stage 2 ) All the batches would be used for NOVA (this seems to correspond roughly to Stage IV in the Proton Plan (PP) document, except that I believe the PP version assumes slip stacking in the Recycler). In his Stage 3, the Booster would run at 15 Hz. Four batches would be inserted into the Accumulator and momentum stacked. Then the 4-batch object would be transferred to the Recycler. This would be repeated 5 more times, using boxcar stacking, thus giving a total of 24 Booster batches that could subsequently be loaded all at once into the MI. This would take 1.6 seconds, about the cycle time of the MI. So once again, this would use all the batches for NOVA.

His idea for KOPIO would involve interrupting his Stage 2 plan. One would run the Booster at 15Hz and use 8 of the batches for NOVA. If no further optimization were done, the cost to NOVA would be 4E12 batches instead of 4.7E12 batches. The beam power for NOVA would then decrease from 722KW to 614KW (for comparison, it is currently 220KW, and when slip-stacking in the MI is fully operational it will be 390KW). This could be alleviated if KOPIO accepted batches with less than 4E12. There would then be 7 batches/second available to KOPIO, although he seemed to foresee us using only 4 [WHY?]. (I imagine momentum stacking in the accumulator for KOPIO so the momentum spread is proportional to the number of batches. Actually, there is no limit except for the momentum spread of the KOPIO Beam. How much momentum spread is okay depends on the extraction process.) These would be sent to the Accumulator and rebunched (this requires building a 240m transfer line from the Booster to the Accumulator). It takes about 260ms to transfer 4 batches, and maybe 30ms to rebunch to 25MHz. However we'd end up using a little more time, i.e. 5 cycles (333ms). He claimed there'd be 7/15 of a second for slow spill, i.e. the duty factor would be a little less than 50% [ACTUALLY THE DUTY FACTOR WOULD SEEM TO BE ONLY 7/15 DIVIDED BY 1.6=0.292]. (You are correct – I don't think well on my feet) The beam would brought out with 3rd integer harmonic extraction - this requires a lot of new hardware. (The Accumulator runs very close to the 2/3 resonance so 3rd integer harmonic extraction looks possible without major modifications to the Accumulator lattice.) Moreover one would need to make a new beam channel off the Accumulator. (I'm not sure what the targeting and extraction requirements for KOPIO would be but there already is an experimental pit in the Accumulator tunnel that was used for a charmonium expermiment. There is a plush counting room above the pit.) Each cycle would contain 16TP and take 1.6sec. Thus there would be 10TP/sec on average. Thus in the time it would have taken for one KOPIO AGS cycle of ~7 seconds, we'd have 70 TP instead of the 100TP we'd have had at the AGS. Also the K/p is only ~0.75 at the same production angle and of course the duty factor is worse. However we'd get to run 10 months/year! With inefficiencies, he thought we'd get ~ 2E20 protons/year.

From what I understand about the microbunching technique, it should work in the Accumulator. I am using momentum stacking to combine booster batches in the Accumulator. At the end of momentum stacking, the beam in the Accumulator is a DC ribbon in which the momentum spread is proportional to the number of batches stacked. A 26 MHz RF system (h=42) would be used to sweep through the beam. A key question is how lossy is this process. Our experience in our Booster is to keep the loss rate below 500W. For 5e16 protons per hour flux, this means that the unwanted loss in the Accumulator should be less than 2.8%

If I put in the 16 TP/cycle, 1.6 sec cycle, live time 7/15 sec, assume 0.75 times as many K's/incident proton (answer very insensitive to this), I find we accumulate sensitivity 0.452 times as fast per hour as KOPIO at the AGS. If one had 2E20 protons/year, this implies 1.25E7 spills or 5556 hours. For RSVP we assumed 2240 KOPIO hours/year at best, so at Fermilab we could accumulate sensitivity at a rate of 1.12 times better per year than KOPIO at the AGS.